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ANALYSIS OF THE MOVEMENT OF THE WORKING BODIES OF THE WOOL PLANT CLEANING MACHINE

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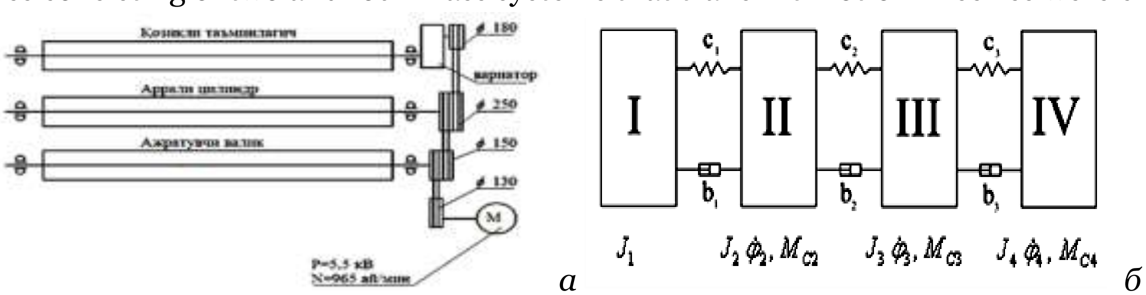
Introduction

Nowadays, the demand for quality natural fibers is growing. For the textile and light industry, it is important that the natural properties of wool are preserved. But the techniques and technologies for obtaining high-quality wool fiber are becoming obsolete, both spiritually and physically. With this in mind, an efficient, resource-efficient design of equipment for cleaning wool from plant mixtures will be developed. This equipment effectively cleans the wool from plant mixtures, maintaining its quality. The efficiency of wool cleaning in the equipment is directly affected by the rotational frequencies, moments of inertia, technological processes, geometric, kinematic and dynamic parameters of the working bodies. Therefore, a dynamic analysis of the equipment was performed to substantiate the parameters of the working bodies.

Keywords: wool cleaning, kinematic, dynamic, geometric, resource-efficient, technological, design.

Dynamic and mathematical models of machine aggregates. The kinematic scheme of the wool plant cleaning machine is shown in Figure 1a. According to the kinematic scheme, the machine uses 2 electric drives, the first of which is driven by a series of belt drives (power 5500 W, n = 100 rad / s), the second by sawing the cleaned pieces of wool. the clutch drum is actuated by a belt drive (power 2200 W, n = 98 rad / s).

Computational schemes structured according to the kinematic scheme are shown in Figure 1b. In this case, schemes consisting of two and four mass systems that transmit motion in series were created.



I-motor rotor and drive pulley mass; II - the mass of the separating shaft, III - the mass of the saw cylinder, IV - the mass of the pile supply,

Figure 1. Kinematic diagram of the cleaning machine (a) and calculation diagrams of machine units (b)

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The equations of motion of working bodies are derived using Lagrange's second-order equations [3,4], for a four-mass system:

$$M_g = f(\dot{\varphi}_1); J_1\ddot{\varphi}_1 = M_g - b_1\Delta\dot{\varphi}_1 - c_1\Delta\varphi_1;$$
$$J_2\ddot{\varphi}_2 = U_{12}(b_1\Delta\dot{\varphi}_1 + c_1\Delta\varphi_1) - b_2\Delta\dot{\varphi}_2 - c_2\Delta\varphi_2 - M_{c2};$$
$$J_3\ddot{\varphi}_3 = U_{23}(b_2\Delta\dot{\varphi}_2 + c_2\Delta\varphi_2) - b_3\Delta\dot{\varphi}_3 - c_3\Delta\varphi_3 - M_{c3};$$
$$J_4\ddot{\varphi}_4 = U_{34}(b_3\Delta\dot{\varphi}_3 + c_3\Delta\varphi_3) - M_{c4} \quad (1)$$

бу ерда $\Delta\varphi_1 = \varphi_1 - U_{12}\varphi_2$; $\Delta\dot{\varphi}_1 = \dot{\varphi}_1 - U_{12}\dot{\varphi}_2$; $\Delta\varphi_2 = \varphi_2 - U_{23}\varphi_3$; $\Delta\dot{\varphi}_2 = \dot{\varphi}_2 - U_{13}\dot{\varphi}_3$; $\Delta\varphi_3 = \varphi_3 - U_{34}\varphi_4$; $\Delta\dot{\varphi}_3 = \dot{\varphi}_3 - U_{34}\dot{\varphi}_4$;

here, M_g, $\dot{\varphi}_1$ - driving moments and angular velocities on the shafts of electric drives; $\dot{\varphi}_2, \dot{\varphi}_3, \dot{\varphi}_4$ - angular velocities of the wool cleaner knocking shaft, saw cylinder, pile feeder and wool picking drum; b_1, b_2, b_3 - the dissipation coefficients of the belt transmissions, respectively; c_1, c_2, c_3 - the virginity coefficients of the belt transmissions, respectively; U_{12}, U_{23}, U_{34} - transmission numbers of belt transmissions; M_{c2}, M_{c3}, M_{c4} - moments of resistance in shafts.

As a result of obtaining numerical solutions of the obtained system of differential equations (1) and (2), the laws of motion of working bodies and connection graphs were determined [5].

A solution of a system of differential equations representing the motion of a machine unit for cleaning wool from plant mixtures was obtained. The following initial conditions were taken into account in obtaining the solution: $t = 0$ if $\dot{\varphi}_1 = 0$; $\dot{\varphi}_2 = 0$; $\dot{\varphi}_3 = 0$; $\dot{\varphi}_4 = 0$.

The following calculated values of parameters are taken into account: drivers *N_1=5500 W; n_1=100 rad/s; c_1=210 N·m/rad; c_2=210 N·m/rad; c_3=150 N·m/rad; J_2=0,141 kg·m^2; J_3=0,21 kg·m^2; J_4=0,064 kg·m^2; M_{c2}=14,8 N·m; M_{c4}=28 N·m; M_{c3}=21 N·m.*

Analysis of theoretical research. On the basis of the numerical solution of the problem, the laws of the working bodies of the machine for cleaning wool from plant mixtures, the saw cylinder, the separating shaft, the pile supplier were determined. The laws of change of angular velocity and torque of the electric drive shaft were also determined. Figure 2 shows a view of the laws of motion of the working bodies of the machine unit for cleaning wool from plant mixtures. In particular, Figure 2a shows the laws of change $\dot{\varphi}_1, \dot{\varphi}_2, \dot{\varphi}_3, \dot{\varphi}_4$ and M1, respectively. It can be seen from the graphs that when the resistance coming from the wool raw material to the pile supplier is 28 N · m, its angular velocity is the amplitude of oscillation and is. Also, when the saw cylinder has an average angular velocity, its vibration amplitude is (2.3 ÷ 2.6) · 10-2 rad / s for the load 21.0 N · m state. Correspondingly, when the load on the separating shaft is 14.8 N · m, the angular velocity oscillation amplitude varies in the range of (1.8 ÷ 2.1) · 10-2 rad / s. In this case, since the random component of the resistance is in the range ±

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(6.0 ÷ 8.0)%, it does not significantly affect the behavior of oscillations of angular velocities. It should be noted that the torque on the shaft of the electric drive varies in the range (4.5 ÷ 9.7) N · m.
When the angular velocity of the pile supplier is reduced, the resistance torque coming from the wool and the vibration frequencies of the working bodies are reduced if the work efficiency is not changed (Figures 3.-a, b). This increases the load on the supply piles (conical). Figure 3b shows the laws of change. At the same time, as the load increases in the transition zone due to the increase of the moments of inertia of the working bodies, the amplitudes of vibration of the angular velocities of the working bodies decrease by 1.5÷2.0 times. This condition can also be observed for the case where the angular velocity of the pile supplier is reduced (Fig. 1b).
As a result of processing the laws of change obtained, graphs of the coefficients of unevenness of the angular velocities of the working bodies of the machine unit of the wool cleaning plant from the plant mixture were plotted against the resistance of the wool and the coefficient of rotation of the belt extension (Figures 2, 3).
Based on the analysis of the graphs, the torque values in the pile feeder correspond to the equipment work productivity, so as the work productivity Ms increases, the coefficients of unevenness of the angular velocities of the working bodies (saw cylinder, pile feeder and separator shaft) decrease linearly (Fig. 4). Including torque
As the angular velocity of the saw cylinder increases from 5.0 N · m to 28 N · m, the coefficient of unevenness d3 increases from 0.024 to 0.126.
Similarly, when the torque of the belt drive, which transmits the motion from the drive to the disengagement shaft, increases from 0.21 · 102 N · m / rad to 2.26 · 102 N · m / rad, the angular velocity of the saw cylinder angularity is 0.15 to 0.026. decreases, where d values are determined based on [6, 7]:

$$\delta_3 = \frac{2(\dot{\varphi}_{3\max} - \dot{\varphi}_{3\min})}{\dot{\varphi}_{3\max} + \dot{\varphi}_{3\min}} \qquad (2)$$

The angular velocities of the remaining shafts of the machine unit, the coefficients of unevenness δ_1, δ_2, δ_4 are also reduced in this law (Fig. 5, Figures 1,2,3). It is known [7] that with increasing masses of working bodies, ie moments of inertia, motion is flattened, velocity oscillations

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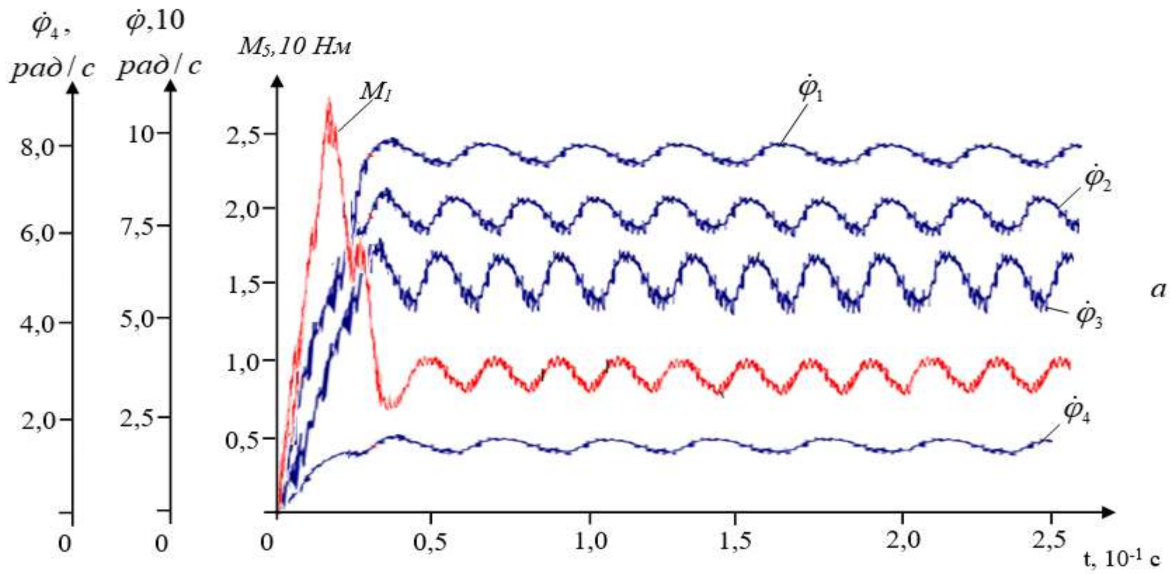
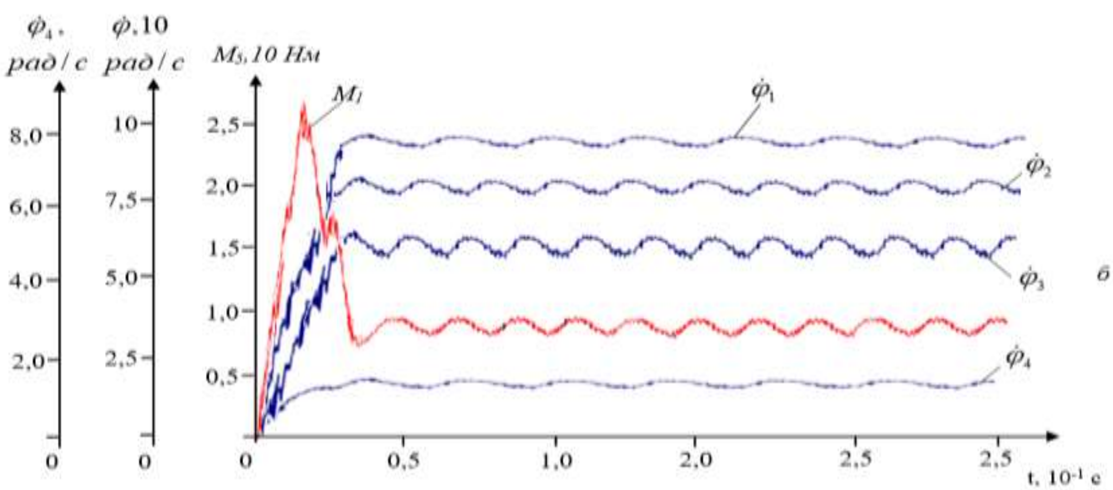


$\dot{\varphi}_{4ўр} = 1{,}67 rad/s$; $c_1 = 210 \frac{N \cdot m}{rad}$; $c_2 = 180 \frac{N \cdot m}{rad}$; $c_3 = 150 \frac{N \cdot m}{rad}$; $J_2 = 0{,}141 kg \cdot m^2$;
$J_3 = 0{,}21 kg \cdot m^2$; $J_4 = 0{,}064 kg \cdot m^2$; $M_{C2} = 14{,}8 N \cdot m$; $M_{C3} = 21 N \cdot m$; $M_{C4} = 28 N \cdot m$



$\dot{\varphi}_{4ўр} = 1{,}67 rad/s$; $c_1 = 250 \frac{N \cdot m}{rad}$; $c_2 = 205 \frac{N \cdot m}{rad}$; $c_3 = 175 \frac{N \cdot m}{rad}$; $J_2 = 0{,}16 kg \cdot m^2$;
$J_3 = 0{,}25 kg \cdot m^2$; $J_4 = 0{,}11 kg \cdot m^2$; $M_{C2} = 14{,}8 N \cdot m$; $M_{C3} = 21 N \cdot m$; $M_{C4} = 28 N \cdot m$

Figure 2. Angular velocities of the drive unit of the machine for cleaning wool from plant mixtures, separating shaft, saw cylinder and pile supply shafts, the laws of change of torque on the drive shaft

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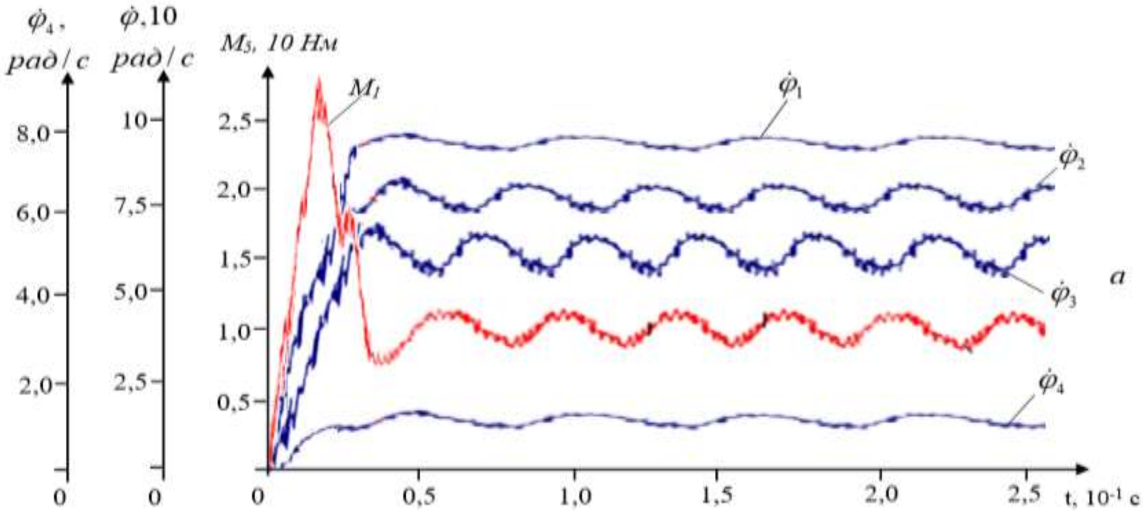
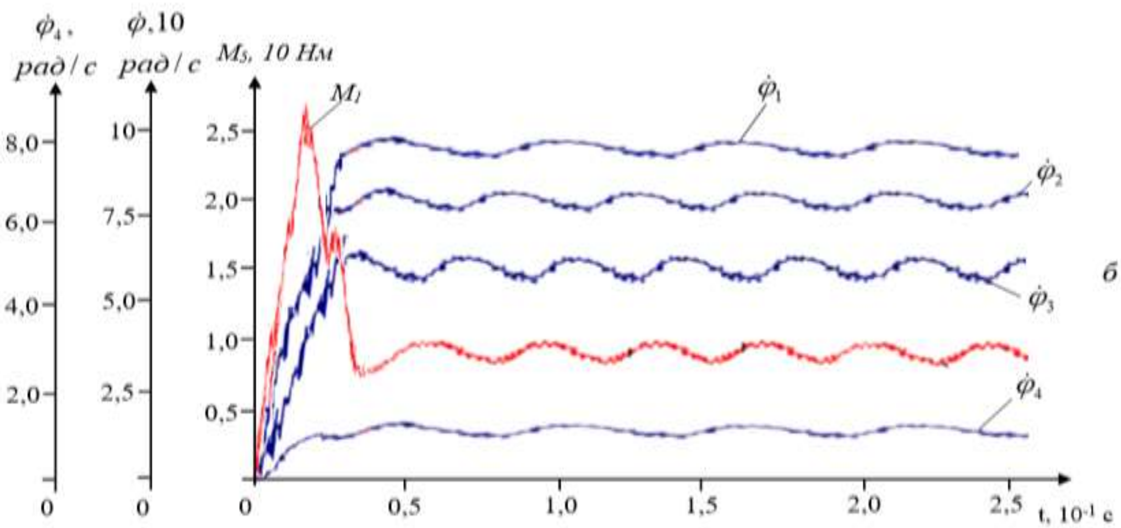


$\dot{\varphi}_{4уp} = 1{,}15\,\text{рад/с}$; $c_1 = 210\dfrac{\text{Нм}}{\text{рад}}$; $c_2 = 180\dfrac{\text{Нм}}{\text{рад}}$; $c_3 = 150\dfrac{\text{Нм}}{\text{рад}}$; $J_2 = 0{,}141\,\text{кгм}^2$; $J_3 = 0{,}21\,\text{кгм}^2$; $J_4 = 0{,}064\,\text{кгм}^2$; $M_{C2} = 14{,}8\,\text{Нм}$; $M_{C3} = 21\,\text{Нм}$; $M_{C4} = 28\,\text{Нм}$



$\dot{\varphi}_{4уp} = 1{,}15\,\text{рад/с}$; $c_1 = 250\dfrac{\text{Нм}}{\text{рад}}$; $c_2 = 205\dfrac{\text{Нм}}{\text{рад}}$; $c_3 = 175\dfrac{\text{Нм}}{\text{рад}}$; $J_2 = 0{,}16\,\text{кгм}^2$; $J_3 = 0{,}25\,\text{кгм}^2$; $J_4 = 0{,}11\,\text{кгм}^2$; $M_{C2} = 14{,}8\,\text{Нм}$; $M_{C3} = 21\,\text{Нм}$; $M_{C4} = 28\,\text{Нм}$

Figure 3. Angular velocities of the drive unit, separator shaft, saw cylinder and pile supply shafts of the machine for cleaning wool from plant mixtures, the laws of change of torque on the drive shaft

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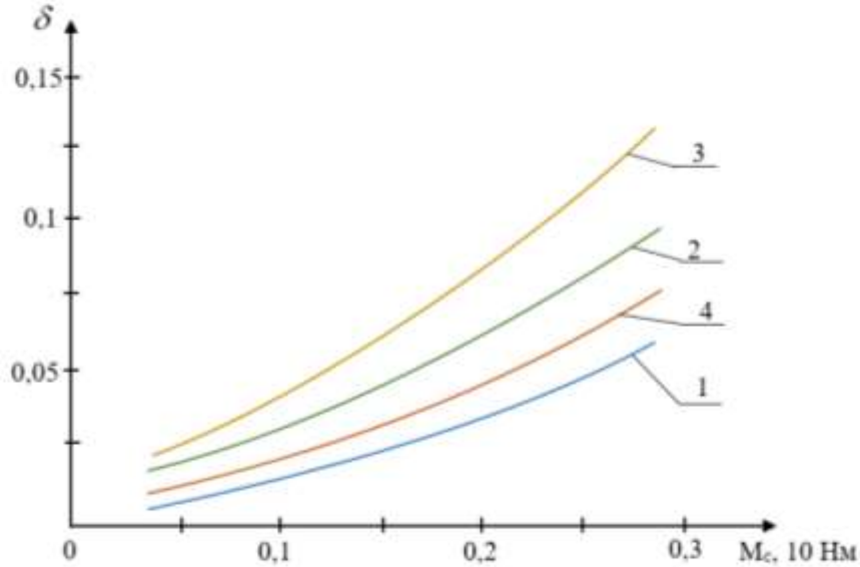
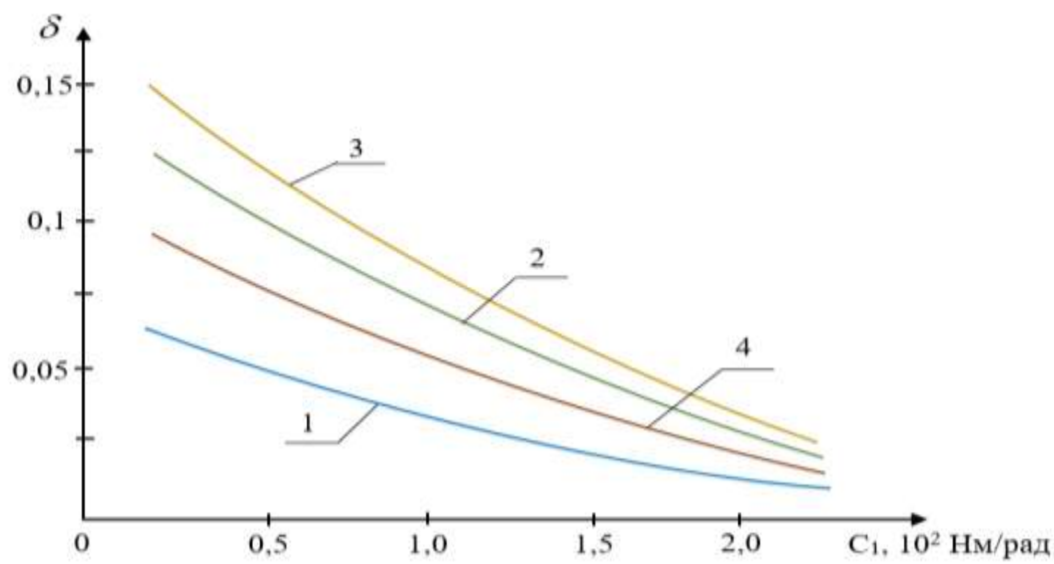


1 - $\delta_1 = f(M_4)$; 2 - $\delta_2 = f(M_4)$; 3 - $\delta_3 = f(M_4)$; 4 - $\delta_4 = f(M_4)$;

Figure 4 Graphs of resistance to the moment of resistance in the shaft, which provides the coefficients of unevenness of the angular velocities of the shafts of the machine unit



1 - $\delta_1 = f(C_1)$; 2 - $\delta_2 = f(C_1)$; 3 - $\delta_3 = f(C_1)$; 4 - $\delta_4 = f(C_1)$;

Figure 5 Graphical connections obtained by changing the coefficient of elasticity of the belt drive, which transmits motion to the shaft, which separates the coefficients of angular velocity of the machine unit shafts from the drive

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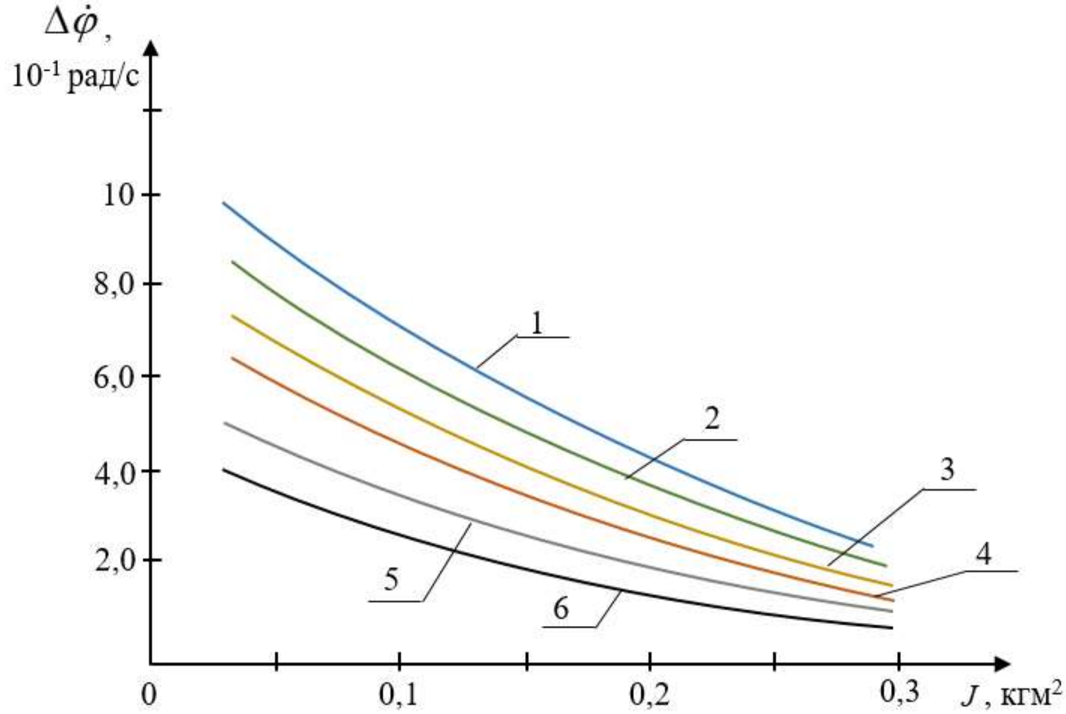

1, 3, 5 - $A\dot{\varphi} = f(J_2)$; 2, 4, 6 - $A\dot{\varphi} = f(J_3)$;

Figure 6. Graphs of dependence of the angular velocities of the shafts of machine units on the moments of inertia of the shaft and saw cylinder separating the vibration coverage

Decreases, but the additional masses lead to an increase in the force, the moment of their movement. Figure 6 shows graphs of the decrease in angular velocity vibration coverage as the inertia torques of the saw cylinder and separator shafts of the machine unit increase.

Based on the analysis of graphs, as well as taking into account the results of experiments [8,9], the following values of the parameters of the machine unit are recommended to ensure the required angular velocities of the shafts: J_1=0,018 kg·m²; J_2=(0,15÷0,16) kg·m²; J_3=(0,22÷0,24) kg·m²; J_4=(0,06÷0,08) kg·m²; c_1=(230÷250) N·m/rad; c_2=(180÷200) N·m/rad; c_3=(160÷170) N·m/rad. Бунда $\delta_3 \le (0,1 \div 0,12)$; $\delta_2 \le (0,08 \div 0,09)$.

Conclusion

Numerical solutions to the problem of the dynamics of the machine for separating wool from plant mixtures were obtained. Saw cylinder, pile supplier, splitter shaft and drive shaft motion laws, connection graphs were constructed, recommended values of parameters were determined.

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